MARS SAMPLE RETURN WITHOUT LANDING ON THE SURFACE. A. J. G. Jurewicz, Steven M. Jones, and A. S. Yen,[1] [1]NASA-Jet Propulsion Laboratory/California Institute of Technology (M/S 183-501, 4800 Oak Grove Dr., Pasadena Ca 91109; JUREWICZ@GPS.CALTECH.EDU).

Introduction: Many in the science community want a Mars sample return in the near future, with the expectation that it will provide in-depth information, significantly beyond what we know from remote sensing, limited in-situ measurements, and work with Martian meteorites. Certainly, return of samples from the Moon resulted in major advances in our understanding of both the geologic history of our planetary satellite, and its relationship to Earth. Similar scientific insights would be expected from analyses of samples returned from Mars. Unfortunately, Mars-lander sample-return missions have been delayed, for the reason that NASA needs more time to review the complexities and risks associated with that type of mission. A traditional sample return entails a complex transfer-chain, including landing, collection, launch, rendezvous, and the return to Earth, as well as an evaluation of potential biological hazards involved with bringing pristine Martian organics to Earth.

There are, however, means of returning scientifically-rich samples from Mars without landing on the surface. This paper discusses an approach for returning intact samples of surface dust, based on known instrument technology, without using an actual Martian lander.

Concept: Recent images of Mars have shown that dust devils are a common occurrence [1]. In addition, local and global dust storms can also introduce micron-sized particles to the upper atmosphere. Estimates of settling times suggest that small particles can remain suspended for months to years [2]. These calculations are compatible with observations of a haze layer located at 20-35 km in altitude [3]. While water and CO_2 ice may be chiefly responsible for the observed haze, its presence is consistent with suspended dust acting as condensation nuclei. An altitude of 35 km is comparable to the aerocapture altitude (40 km) originally planned for the Mars sample return orbiter. Thus, it may be possible to collect high-altitude dust samples from an orbital vehicle for return to earth. Collection of suspended particles could provide a sampling of the fine particles in the global soil unit and, accordingly, valuable insight into geologic processes on Mars.

Prior Art: Previously, many techniques have been used to collect small particles for scientific analyses. The scenario proposed later in this paper is based in great measure on the following two methods:

1. Earth-based. High-altitude, supersonic planes such as the SR-71 Blackbird are routinely equipped with a silicon-oil containment vessel for catching dust at high speeds in the upper atmosphere. Because we are usually not interested in the composition of Earth dust, we sort through the collected material, looking for micrometeorites and interstellar dust particles.

2. Deep space. The *Stardust* and *Genesis* missions will sample cometary dust and the solar wind, respectively, by exposing collector arrays to particle streams. Hypervelocity impacts implant material in collectors which are effectively stationary relative to the particles. The collectors are subsequently returned to earth for laboratory analysis or the captured material.

Clearly, both of these exact approaches are impractical on Mars. We are not going to send up an SR-71, nor are the Martian dust particles going to hit passive collectors at hypervelocities. However, sending a high-altitude, supersonic craft into the Martian upper atmosphere to collect suspended particles may be possible.

Candidate scenario: Consider an orbiting satellite monitoring the vertical profile of dust in the Martian atmosphere. During a period of intense dust activity it could execute a deorbit burn, thus dropping the periapsis to an altitude compatible with collecting dust samples. Collection of the particles would involve an approach similar to that employed on the *Stardust* spacecraft: Aerogel would be used to capture the dust. The collectors would then be retracted into the spacecraft and returned to earth for extraction and analysis of the samples.

There is obviously a tradeoff between achieving a sufficiently low altitude to collect many dust particles and not overheating the spacecraft or ablating the exposed collector. However, the trajectory, the speed of the pass, the duration of the collection period, and the composition and physical characteristics of the aerogel itself can all be optimized.

Aerogel: Aerogel has the unique property of stopping particles impacting at hypervelocities while keeping the bulk of the impactor intact. It is also lightweight, tough, and resistant to high temperatures.

To date, all of the experiments which use aerogel as particle collectors employ silica aerogel. Silica aerogel is optically clear-to-translucent, which makes it easy to identify and locate particles after they have been captured. Earlier workers worried about the purity of the aerogel degrading scientific analyses of carbon-bearing IDP's [4]. However, since aerogel is made from liquids, these can be purified/distilled at the start of the process, and residual organics removed by a bake-out step at the end of the process. Indeed, ICP-MS analysis on *Stardust* aerogel showed inorganic impurities at the ppm range and modest heating resulted in carbon content of ~ 0.5% (wt%).

A short history of aerogel capture as part of the evaluation and analysis of particles from an intact-capture experiment placed on the MIR space station, which, is given in [5].

A photomicrograph of a particle captured in aerogel. This particle was implanted by hypervelocity impact testing for the *Stardust* mission. The aerogel itself is a low-density layered silica-aerogel which was being tested as a capture medium for interstellar particles. This particular particle (black) is diamond, approximately 30 microns in diameter. The associated, irregular lines around it (running sub-vertically through the picture) are the track the particle made in the aerogel.

Although silicon aerogel is excellent for intact capture of particles, we believe that there may be better materials available. The primary problem with silicon aerogel is that many of the particles that we would capture while collecting Martian dust would also be silicates. The surfaces of the silicate particles would interact with the silica aerogel during capture because, during the capture, the kinetic energy of the particle is converted in part to heat. While this is good in that it mitigates any Martian biohazard, it also means that the outermost portion of the captured particles is generally ablated. The silica aerogel would make it much more difficult to reconstruct the outer, ablated portion of the captured particle.

Aerogel does not have to be made from silica, however. Aluminum, zirconium, titanium, tin and a variety of other oxide aerogels have been produced. In non-silicate aerogel, it may be more difficult to locate the captured particles, because the aerogel tend be translucent or opaque. Still, technology that would be useful for locating these particles through other than visual means (e.g., x-ray imaging; [6],[7]) does exist.

Once the particle is located, it would be less of a problem separating the chemistry of the original silicate particle from the surrounding aerogel. This better understanding of the chemistry of the captured particle would clearly increase the science return.

Tin-oxide aerogel is potentially an outstanding candidate non-silicate aerogel in that it is transparent [8, 9], allowing for optical location and retrieval. Perhaps more important, tin oxides have also been shown to exhibit selective adsorption of certain gases such as CO, CO_2, CH_4, C_2H_5OH, NO_2, NO_X, etc. [10]. Thus, if these gases were released during the capture of a hydrated or non-silicate particle, they would tend to be adsorbed by the oxide network and thus captured along with the non-volatile material.

Summary: Given our current technology, sending in a high-altitude, supersonic craft for intact capture of suspended particles using aerogel may be a real possibility. The spacecraft trajectory, the speed of the pass, the duration of the collection period, and the composition and physical characteristics of the aerogel itself can all be optimized for the mission. For example, we note that, for the *Stardust* mission, gradient density aerogel was developed. Subsequently aerogel with other gradient properties, i.e., dopant, oxide, etc., have been produced [11]. So, by being able to control the properties of the aerogel, collectors can be tailored to optimize the capture the type of dust present.

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